Available online at www.sciencedirect.com
ScienceDirect
Procedia - Social and Behavioral Sciences 174 (2015) 1285 – 1291
Procedia
Social and Behavioral Sciences

INTE 2014

Qualimetric researches of educational resources: standardizing of light conditions in the light booth

Alexander P. Sergeev[a]*, Dmitry A. Tarasov[a], Sergey Y. Arapov[a], Svetlana P. Arapova[a]

[a]*Ural Federal University, Department of printing arts and web-design, Mira, 32-R041, Ekaterinburg 620002, Russia*

Abstract

The work presents a simple solution for the development of universal light booth, providing the conditions for viewing pictures, texts and other samples in accordance with ISO 3664:2009. The booth is designed for use in a qualimetric researches of educational resources which are involve both children and adults. It was tested in practical studies embracing reading and image assessment. The appliance is built of inexpensive and disposable materials.

Peer-review under responsibility of the Sakarya University

Keywords: Education; Light; Picture; Qualimetrics; Standard; Text; View

1. Introduction

While spectral, colour and density measurements play important roles in the control of colour reproduction, they cannot replace the human observer for final assessment of the quality of complex images. Colour reflection artwork, photographic prints, images on monitors, and reproductions are commonly evaluated for their image and colour quality, or compared critically with one another for fidelity of colour matching. Paper and other substrates contribute to the colour appearance and controlling the colour of these is equally critical. All this requires a certain viewing conditions, which are described in some international standards, such as ISO 3664 (2009). It's known that the most important feature of light is photometric brightness of a stimulus. As Daly S. (1993) showed, it concerns both the colour assessment and qualimetrics measures. All of that are the different kinds of psychophysical studies.

There is no doubt that the best viewing condition for the visual assessment is that in which the product (stimulus) will be finally seen. Since deficiencies in light sources and viewing conditions, and inconsistencies between colour

* Corresponding author. Tel.: +7-919-373-8574; fax: +7-343-375-4630.
E-mail address: alexanderpsergeev@gmail.com

Peer-review under responsibility of the Sakarya University
doi:10.1016/j.sbspro.2015.01.749

viewing facilities, can distort the colour appearance of substrates, reproductions and artwork, they are likely to cause miscommunication about colour reproduction and processing. The International Standard (ISO 3664, 2009) provides specifications for illumination and viewing conditions that, when properly implemented, will reduce errors and misunderstandings caused by such deficiencies and inconsistencies. The illumination used to view colour photographic prints, reproductions, and images on monitors needs to provide adequate amounts of radiant power from all parts of the ultraviolet and visible spectrum to avoid distorting their appearance from that observed under commonly used sources of illumination such as daylight. To avoid further miscommunication, all the terms and definitions used in this study are applied in accordance with CIE 17.4 (1987). The reference spectral power distribution specified in ISO 3664 (2009) is CIE Illuminant D50 by CIE 051.2 (1999) which simulate natural daylight quite accurately and has correlated color temperature about 5000 K. Many of the reasons for the selection of illuminant D50 are done in ISO 3664 (2009), as opposed to any other CIE daylight illuminant, are equally applicable today (D55, D65). Spectral power distributions of that illuminants are showed in Fig. 1 Because it is very difficult to produce artificial sources of illumination which closely match the spectral power distribution of daylight, it is important that the tolerances specified within ISO 3664 (2009) provide a compromise between that required for lamp manufacturing purposes and that for consistent viewing.

The chromaticity, which directly defines the colour of the illumination at the viewing surface, is specified as that for illuminant D50 and the tolerance by a circle in the CIE 1976 Uniform Chromaticity Scale (UCS) diagram having a specified radius around that value by ISO 11664-5 (2009). To establish the compliance of the spectral power distribution of the illumination to that of illuminant D50 the methods defined in CIE Publications CIE 013.3 (1995) and CIE 051.2 (1999) are both specified. One defines the colour rendering quality of a lamp; the other its ability to correctly predict metamers. Every precise illuminant should has a color rendering index (CRI) assigned. CRI of illuminant for the color assessments shouldn't be less than 90 %.

Computer monitors are often being used to display and view digital images and texts in graphic technology, photography and research assessments. In order to ensure consistency of assessment in this situation it is important that the viewing conditions in which the monitors are placed are reasonably well specified ISO 12646 (2008). The perceived tonal scale and colours of a print or picture on monitor can be significantly influenced by the chromaticity and luminance of other objects and surfaces in the field of view. For this reason, ambient conditions, which may affect the state of visual adaptation, need to be designed to avoid any significant effects on the perception of colour and tone and immediate surround conditions need to be specified also ISO 5-4 (2009). Experience in the industries covered by ISO 3664 (2009) has revealed the need for two levels of illumination; a high level for critical evaluation and comparison, and a lower level for appraising the tone scale of an individual image under illumination levels similar to those under which it will be finally viewed. The appliance describing in this work provides both levels of illumination. The high illumination level on surface is equal to 2000±500 lux, the low level is equal to 500±125 lux.

The aim of this study was to create a cost-effective solution for the development of universal light booth, providing the conditions for viewing pictures, texts and other samples in accordance with ISO 3664:2009, as well as having mobility, durability and illumination variation for different viewing conditions, including prospective studies.

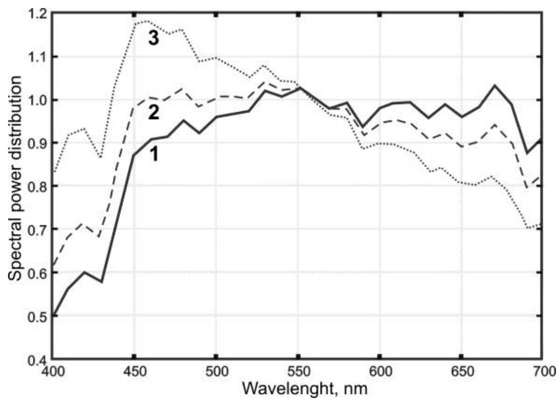

Fig. 1. Spectral power distribution of illuminants CIE D: 1 – D50, 2 – D55, 3 – D65.

2. Short review of existing solutions

Nowadays much consideration was given to changing the reference illuminant to be CIE F8, a 5000 K illuminant more typical of fluorescent lamps. However, it was felt that this would provide only a minimal conformance advantage and the actual goal is for the illumination to simulate natural daylight. In spite of it, a lot of light booths and chambers based on fluorescent lamps are currently on the market. Most of them have some disadvantages: flare lights, short lifetime of lamps, high price etc.

In work of Farnand S. et al. (2012) a survey of 13 most common on the market D50 light booths used throughout the print production workflow was conducted. All of them are based on fluorescent lamps. Fluorescent lamps are produced in many different forms. Linear fluorescent lamps, such as those used in viewing booths, are commonly specified as either T12 or T8. Fluorescent lamps operate when low-pressure mercury vapor is energized from an electric current inside of a lamp. The excited mercury vapor emits UV and visible radiation. Phosphors coating the inner walls of the lamp absorb the UV radiation and re-emit it in the visible spectrum. The type of phosphors used, along with the visible mercury emission, determine the spectral power distribution of the light source. The most common color temperatures for T8 lamps are 3500 K and 4100 K. However, the color rendering properties of these lamps can vary greatly. T8 lamps are classified within the industry by their CRI. Those lamps with CRIs between 70 and 79 are classified as RE70 lamps; those with CRIs between 80 and 89 are classified as RE80 lamps, and those with CRIs greater than 90 are classified as RE90 lamps. However, it is also important to remember that fluorescent lamps are often tuned to produce a specific CRI value, which only guarantees proper rendering of the eight CRI samples. The spectral power distributions for all thirteen viewing booths are shown in Fig. 2. CIE illuminants F8 and D50 are shown for comparison.

In Fig. 2 the specific fluorescent peaks in short-wave and middle-wave areas can be seen well. These peaks are not corresponded to the smooth spectrum of CIE D sources. These are the main reason for the relatively low color rendering indexes of all fluorescent lamps. However, they’re cheap. Therefore a fluorescent lamps are widely used in light booth’s manufacturing.

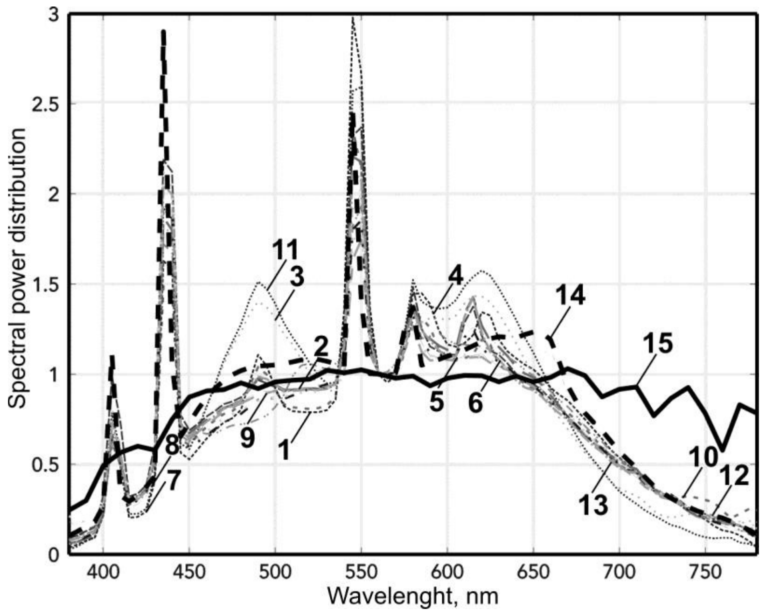

Fig. 2. Spectral power distribution of illuminants in light booths, F8 and D50: 1 – JUST Normlicht Color Control Professional (Customer); 2 – JUST Normlicht Color Control Professional (Pre-Press); 3 – Heidelberg Press Booth (press); 4 – Heidelberg Prinext Press Center; 5 – GTI CVX Color Viewing Station (on-press); 6 – GTI CVX Color Viewing Station (quality); 7 – GTI CVX Color Viewing Station (pre-press); 8 – GTI CVX Color Viewing Station (in-line); 9 – GTI CVX Color Viewing Station (digital); 10 – GTI GraphicLite LiteGuard; 11 – Heidelberg Press Booth (check); 12 – GTI ColorMatcher; 13 – GTI GraphicLite Executive Viewing Station; 14 – F8; 15 – D50 (Farnand et al., 2012).

3. Development of the booth and results

Based on the conditions ISO 3664 (2009) and features of modern lamp, it was decided to look for a halogen lamp as light source. It is physically close to the natural sunlight and widely available on the market. Halogen lamps have a maximum brightness with minimum size. As a base illuminator lamp OSRAM Decostar 51 Cool Blue was selected (Osram, 2013). The main features of the lamp are following: long life (4000 hours), low price (about $10), CCT 4500 K, CRI 95 %, light power 1200 cd, voltage 12 V, wattage 50 W, possible smooth adjustment of the operating voltage. The lamp has a smooth "thermal" spectrum without any extraneous peaks, and without a "hump" in the long wavelength region of the spectrum. Such not typical for the filament lamps colorimetric characteristics are achieved, in particular, by applying an interference filter which attenuates longer wavelengths of halogen spectrum and brings it close to the spectrum of standard CIE D illuminators. The spectral power distribution of Decostar 51 is shown in Fig. 3. CIE illuminants F7 and D50 are shown for comparison.

The preliminary studies have shown that CCT of the lamp does not comply with the standard ISO 3664 (2009) at an operating voltage. Moreover, the lamp provides insufficient lighting. It was decided to use the lamp in the overvoltage mode, whereby it is possible to raise both CCT, and light output. Subsequent experiments showed that even at 15 V the lamp provides CCT about 4800 K, which corresponds to the requirements of ISO 3664 (2009). Moreover, a single lamp is able to provide the illumination of 500 lux on the viewing table, which is sufficient for assessing the low level of illumination.

It was found that the lamp in overvoltage mode is well tolerated. In the experiments a supply voltage rose up to 21 V, the power consumption exceeded 100 W. Since the conditions of such intense lamp’s heating, its electrical properties in the circuit are nonlinear. The main electrical characteristics were measured, they are shown in Fig. 4.

It should be noted that the IV-curve of the lamp is almost linear throughout the range of voltages 12-19 V, and electrical parameters remained virtually unchanged for different instances. Using the lamp in the overvoltage mode is interesting primarily because it allows to achieve higher CCT. Behavior of the photometric characteristics and CCT depending on the voltage is shown in Fig. 5. The measurements were performed in a large dark area away from the surfaces at a distance of one meter from the lamp on its central axis. The spectrophotometer used was X-Rite ColorMunki with Argyll CMS software package. When creating the illuminators, it was considered the fact that the interference filters have a significant dependence of the spectral transmittance of the light flux incidence angle. To reduce the effect of angular CCT decreasing the conical diffuse reflector with an opening angle of 30 angle degrees and a surface with spectral reflectance of 30 % was applied. As experience has shown, this decision proved quite effective.

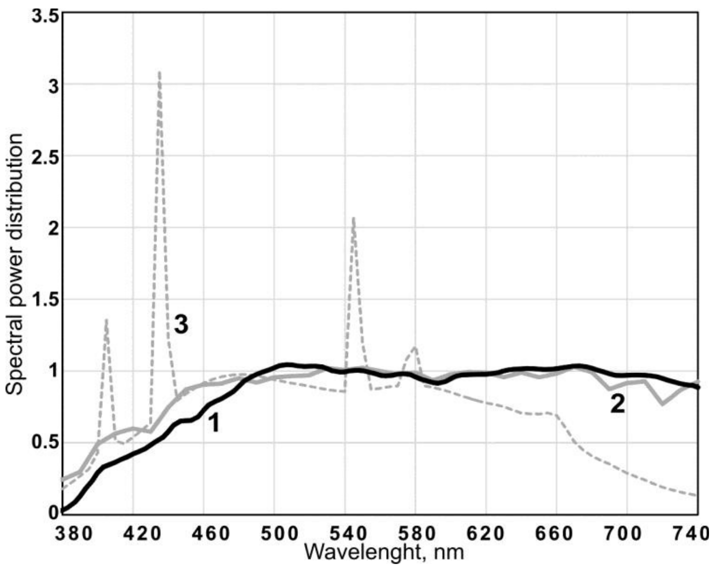

Fig. 3. Spectral power distribution: 1–Decostar 51 Cool Blue lamp, voltage 16.5V; 2– CIE D50; 3– CIE F7.

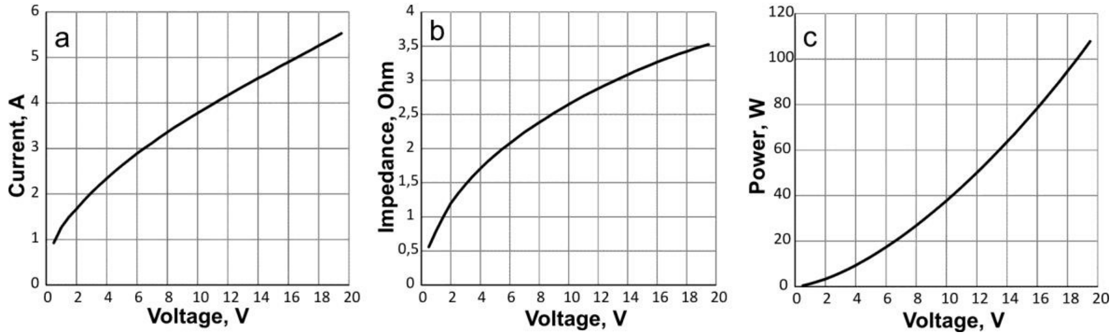

Fig. 4. Electrical characteristics of Decostar 51 Cool Blue lamp over a wide range of voltages: a – IV curve; b – resistance change; c – power consumption.

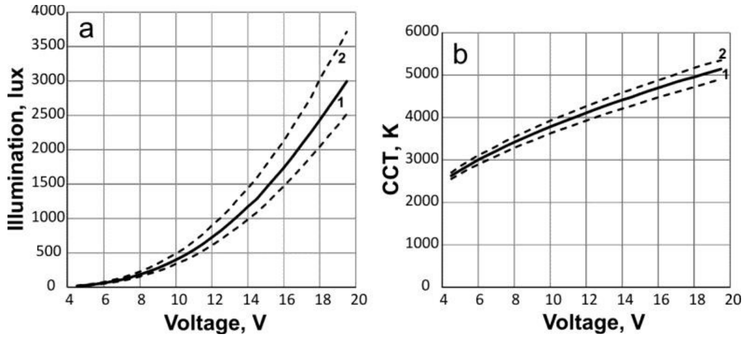

Fig. 5. Dependence on voltage: a – illumination; b – CCT: 1 – mean value, 2 – range of value.

The power supply of the lamps was carried out in two symmetrical electrical wiring where the laboratory autotransformers with voltage regulation where used. The input alternating voltage 220 V, 50 Hz is fed to terminals of transformers and then after the two step reduction it's applied to the lighting components adjusting in the range of 0-17 V. To facilitate the registration of the power consumption the alternating voltage is rectified by a diode bridge. The lamp voltage was measured by digital multimeters. Schematic diagram of the power supply is shown in Fig. 6.

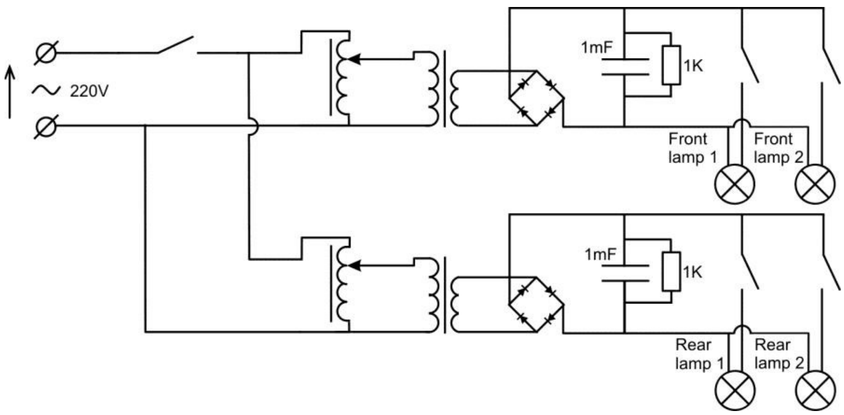

Fig. 6. Schematic diagram of the power supply.

The booth box is made completely isolated from the outside to remove ambient light. The observer located inside the booth within the experiments. It also promotes better luminance and chromatic adaptation of the observer. To unify and facilitate assembly and disassembly the camera frame is made of typical items for metal shelving: perforated racks and shelves. As a light-blocking material the black tarpaulin cloth has been applied. It also provided the possibility of natural ventilation of the inner room. The partition separates the inner room from the external control zone was made from aluminum sheet coated with matt achromatic dye that provides reflectance of about 30 %. The illuminators where made of sheet aluminum. For better handling and more uniform illumination the dual lamps where used. To provide background lighting of the inner room the another dual lamp where added. They're located behind the observer and covering the upper part of the booth by dint of a polyethyleneterephthalate film reflector above the observer's table and under the lamps translucent diffusing screen was installed. Thus the light booth was built. Its overall dimensions - 2480×1040×2340 mm. Exterior and interior of the light booth is showed in Fig. 7.

To verify the compliance with parameters specified the series of twenty measurements of lighting on the surface inside were done. After the measurements the mean values where calculated. Measurements were made with a spectrophotometer X-Rite ColorMunki. Data from the spectrophotometer was treated in the Argyll CMS software package. The compliance with the standard spectrum of the source CIE D50 is demonstrated in Fig. 3. The average luminance value on the table was 510 lux. Average CRI was 98.7 %. Thus, a universal light booth is fully compliant with ISO 3664 (2009) in terms of lighting conditions for consumer evaluation (low level). Four units of lamps provides about 1800 lux of illumination. It corresponds to the expert assessment (high level) according to ISO 3664 (2009). The shape of the spectrum is not changed. CRI is significantly above 90 %.

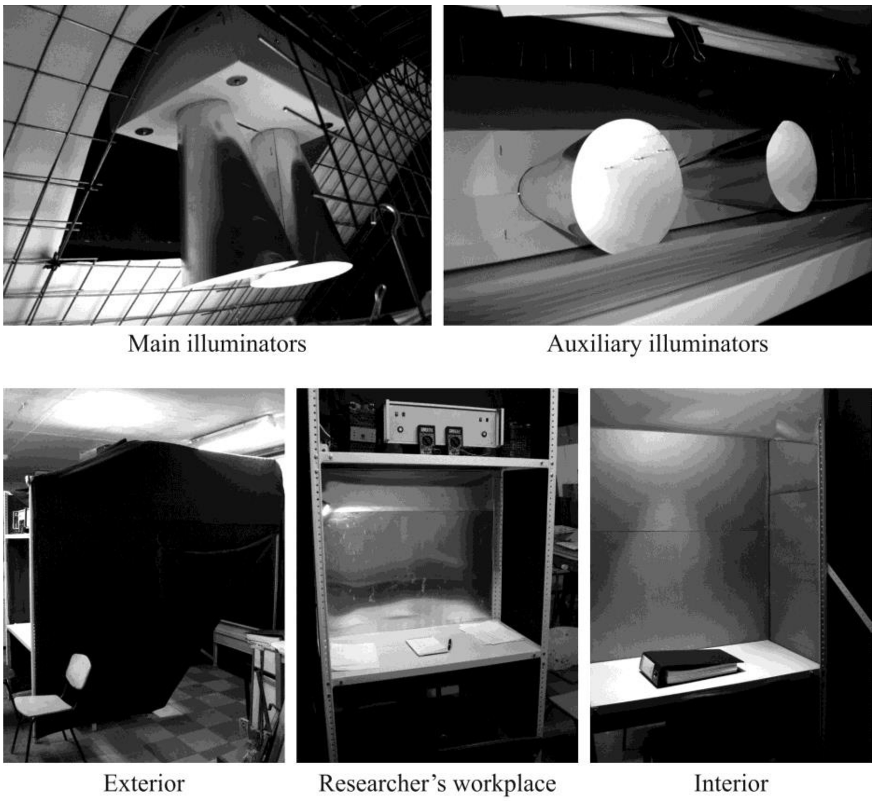

Fig. 7. Universal light booth.

4. Conclusion

For the modeling of the standard viewing conditions the isolated universal light booth developed. The testing has shown that it meets the requirements of ISO 3664 (2009). The costs of building were about $500. Thus, the cost-effective solution for viewing under standardized lighting conditions proposed. This universal light booth was used during the psychophysics and qualimetric studies (Tarasov et al., 2012) at the Department of Printing arts and web design of Ural Federal University, Ekaterinburg, Russia. A new research methodology based on use of this booth developed (Tarasov et al., 2013). The lamps have already worked for more than 100 hours. There is no significant change in light and spectral characteristics noted. The booth developed is recommended to use in all kinds of qualimetric researches.

References

ISO 3664 (2009). Graphic technology and photography – Viewing conditions. ISO 3664:2009. Geneva: ISO, 2009, 34 p.

Daly S. (1993). The Visible Differences Predictor: An algorithm for the Assessment of Image Fidelity. *Digital Images and Human Vision*, A.B. Watson, editor. Massachusetts. Cambridge: MIT Press, 1993, 179-206.

CIE 17.4 (1987). International Lighting Vocabulary. CIE 17.4-1987. 4th edition. Paris: CIE, 1987, 365 p.

CIE 051.2 (1999). A Method for Assessing the Quality of Daylight Simulators for Colorimetry CIE 051.2-1999. Paris: CIE, 1999, 30 p.

ISO 11664-5 (2009). Colorimetry – Part 5: CIE 1976 L*u*v* Colour space and u', v' uniform chromaticity scale diagram. ISO 11664-5:2009 (CIE S 014-5/E:2009). Geneva: ISO, 2009, 9 p.

CIE 013.3 (1995). Method of Measuring and Specifying Colour Rendering Properties of Light Sources. CIE 013.3-1995. Paris: CIE, 1995, 20 p.

ISO 5-4 (2009). Photography and graphic technology – Density measurements – Part 4: Geometric conditions for reflection density. ISO 5-4:2009. Geneva: ISO, 2009, 15 p.

ISO 12646 (2008). Graphic technology – Displays for colour proofing – Characteristics and viewing conditions. ISO 12646:2008. Geneva: ISO, 2008, 18 p.

Farnand S. et al. (2012). Evaluating the impact of the variability of D50 light booths on the appearance of reproductions of monochrome photographs [a research monograph]. Rochester, NY: RIT School of Print Media, 2012, 5-20.

Osram (2013). [Electronic source]. http://www.osram.com/osram_com/products/lamps/halogen-lamps/decostar/decostar-51-cool-blue/index.jsp. Accessed 01.10.2013.

Tarasov D.A., Fominykh O.A., Sergeev A.P., Arapova S.P. (2012). Resolution as a predictor of qualimetric solutions on the example of achromatic prints. *Proceedings of the higher educational institutions. Problems of printing and publishing*, 6, 2012, 81-91. (On Russian. Тарасов Д.А., Фоминых О.А., Сергеев А.П., Арапова С.П. Разрешение как предиктор квалиметрического решения на примере ахроматических оттисков // Известия высших учебных заведений. Проблемы полиграфии и издательского дела. 2012. № 6. С. 81-91.)

Tarasov D.A., Sergeev A.P., Kornilova Y.I. (2013).The leading as a factor of reading speed on the example of paper and web texts. *Proceedings of the higher educational institutions. Problems of printing and publishing.* 2, 2013, 81-88. (On Russian. Тарасов Д.А., Сергеев А.П., Корнилова Ю.И. Интерлиньяж как фактор скорости чтения на примере бумажных и веб-текстов // Известия высших учебных заведений. Проблемы полиграфии и издательского дела. 2013. № 2. С. 81-88.)